Inland Navigation

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1. Description of Inland Navigation System

2. Economic Evaluation

3. Case Study

Inland Navigation System

Inland navigation system is a system of lock and dam projects that convert natural rivers with their variable water levels into a waterway system with a constant depth that is sufficient for the reliable movement of commercial vessels.

Natural River

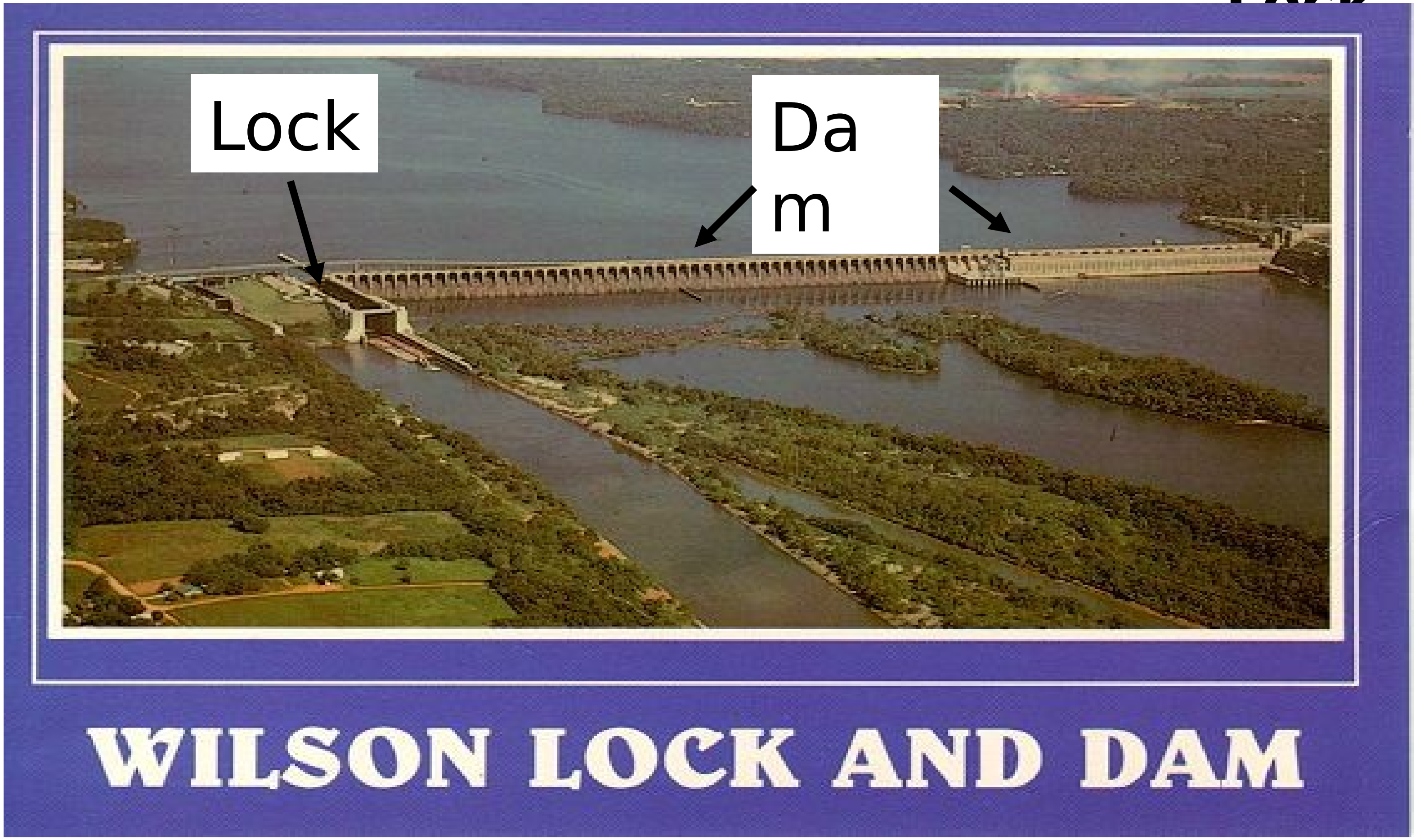
Lock and Dam Projects

1. Dams convert the river into a series of lakes (pools).

2. Locks allow vessels to pass from one pool to the other.

Dam without Lock

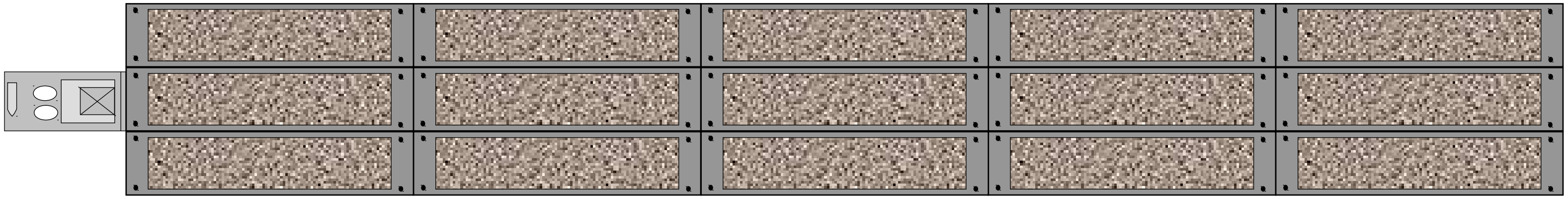
Dam with Lock



Typical Ohio River

15 Barge Tow

Overhead View



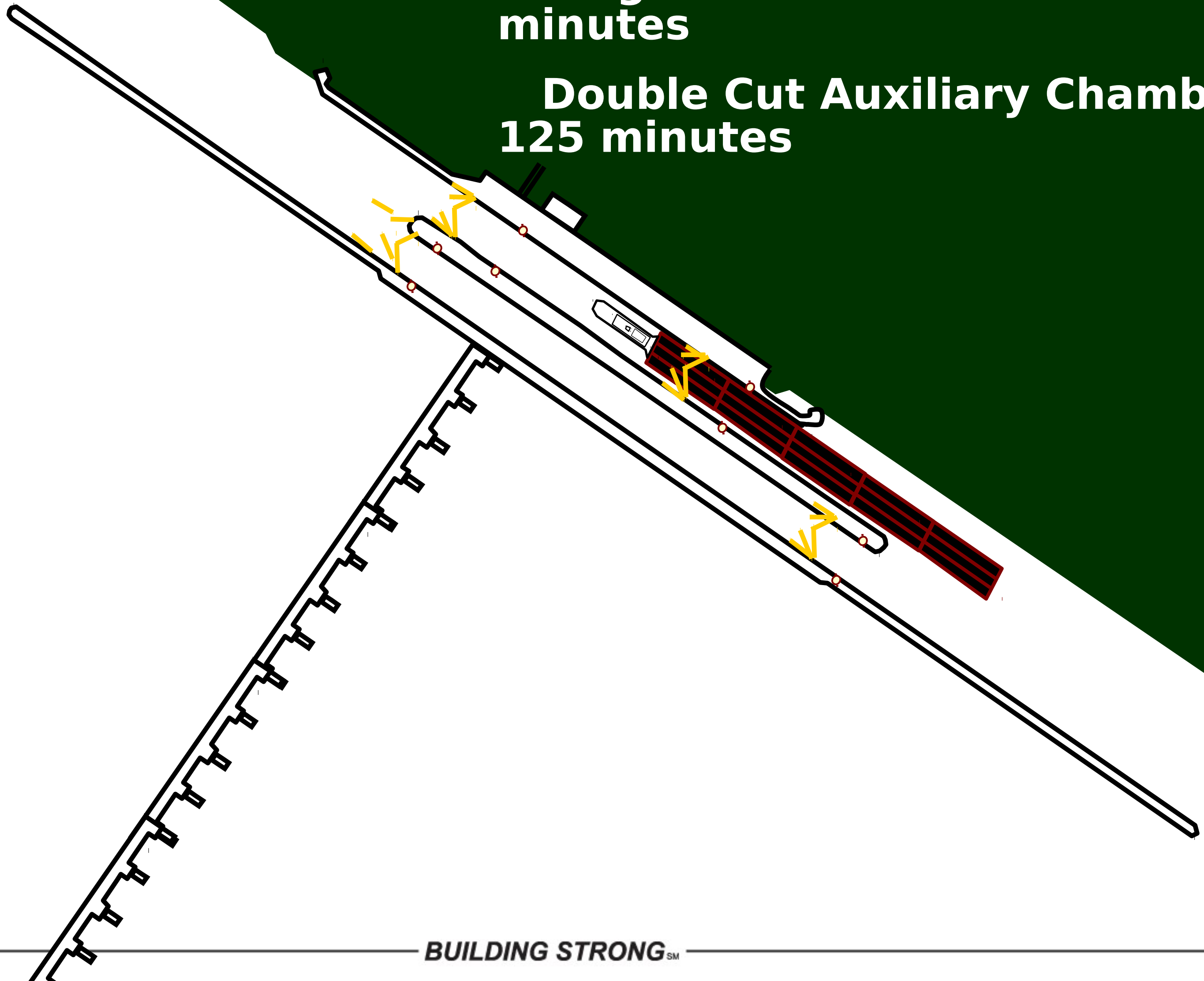
Side View

1200’ x 110’ and 600’ x 110’ Mainstem Ohio Project

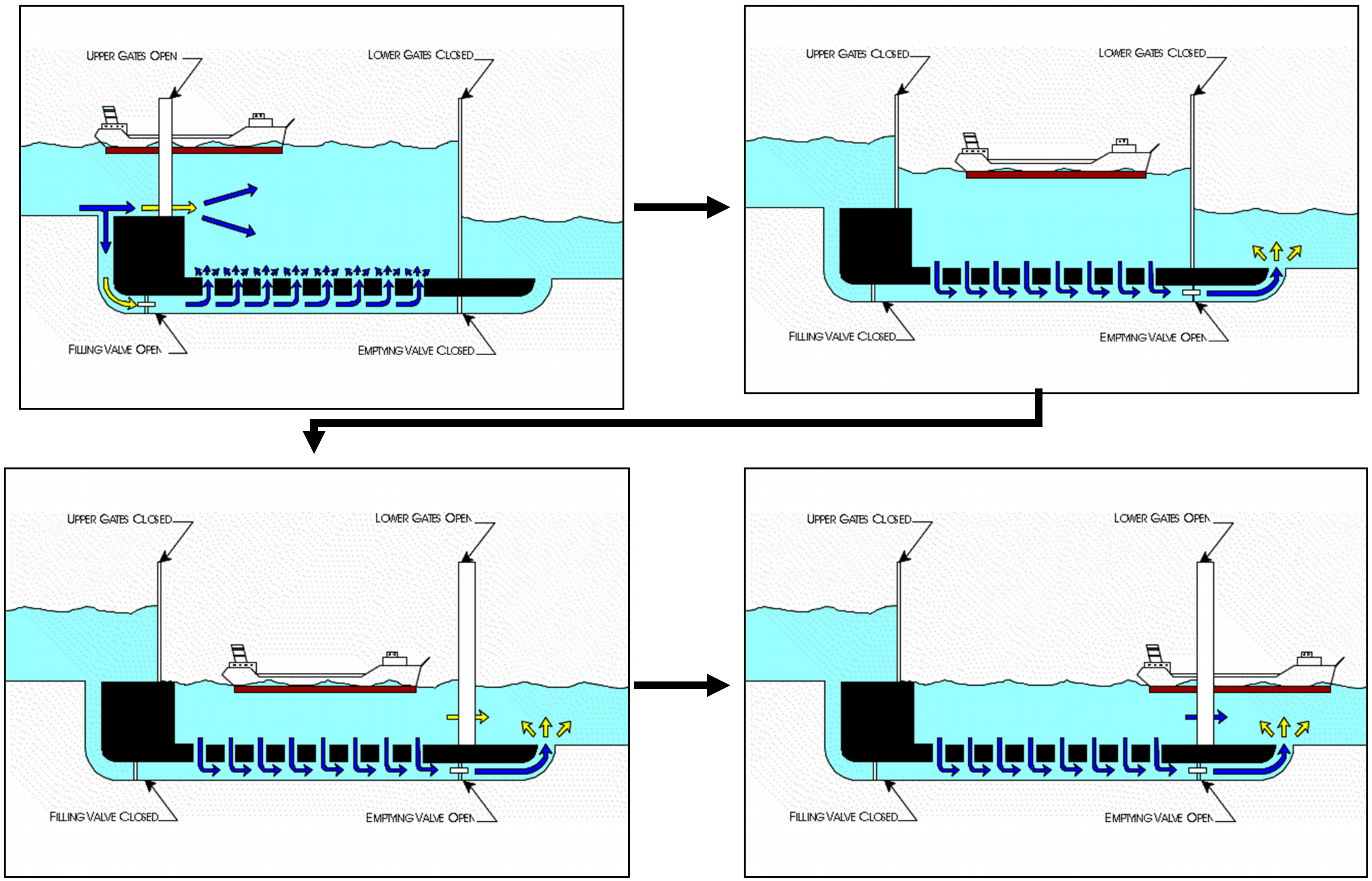
Typical 15-Barge Tow

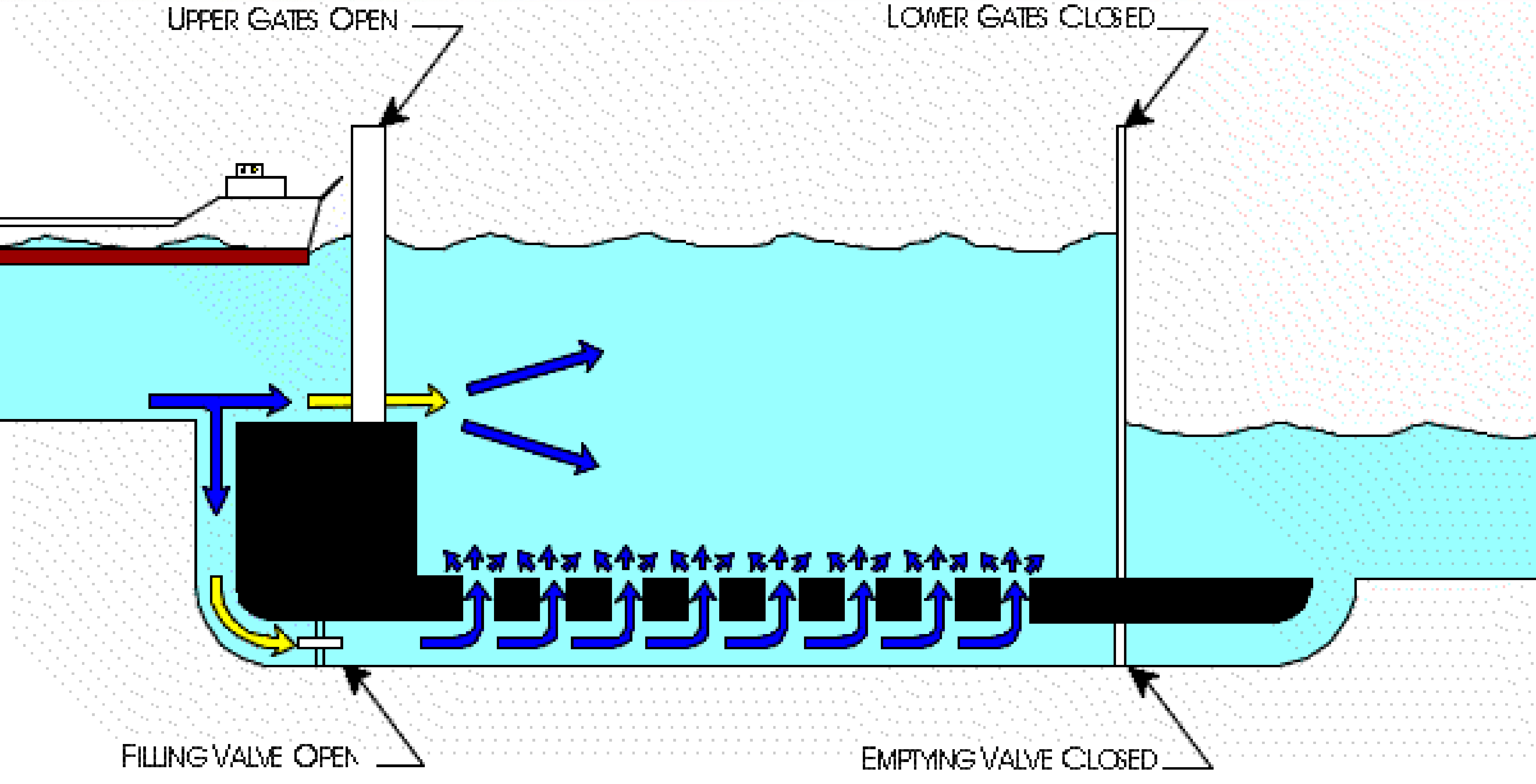
Single Cut Main Chamber = 60 minutes

Double Cut Auxiliary Chamber = 125 minutes



Operation of a Lock

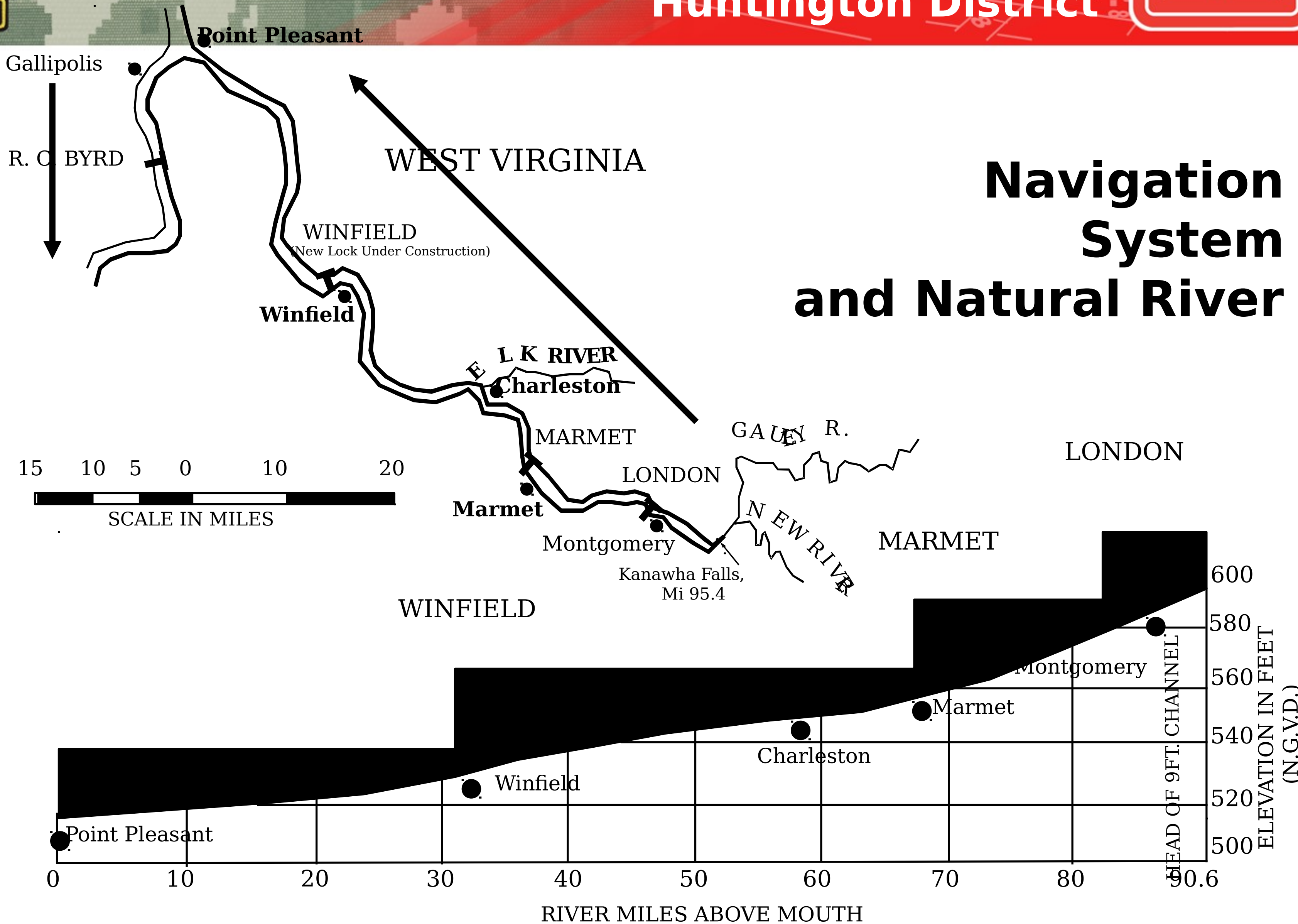



UPPER GATES OPEN
LOWER GATES CLOSED
FILLING VALVE OPEN
EMPTYING VALVE CLOSED

Navigation System

A series of lock and dam projects that convert a natural river system into a commercially navigable system.

Navigation System and Natural River




The Inland Waterway System
334 Milage Between Cities
3 Number of Locks
Minneapolis, MN
Upper Mississippi R.
Milwaukee, WI
637
27
Chicago, IL
Illinois R.
326
7
Cincinnati, OH
165
2
40
1
58
1
Charleston, WV
Huntington, WV
72
8
Allegheny R.
Pittsburgh, PA
Monongahela R.
265
9
129
9
Fairmont, WV
Kansas City, MO
290
Missouri R.
St. Louis, MO
39
2
141
2
Ohio R.
Louisville, KY
322
5
179
0
48
2
Paducah, KY
229
0
215
3
Knoxville, TN
188
3
Chattanooga, TN
249
4
Tennessee R.
Tulsa, OK
334
11
Arkansas R.
Memphis, TN
Little Rock, AR
110
6
127
0
451
12
Jefferson City, MS
Tennessee-Tombigbee Waterway
Columbus, GA
Apalachicola-Chattahoochee R.
Lower Mississippi R.
295
0
Baton Rouge, LA
Natchez, MS
Mobile, AL
29
0
218
0
123
0
134
2
134
1
New Orleans, LA
255
0
95
0
Houston, TX
52
0
139
1
Corpus Christi, TX
142
0
Brownsville, TX
200
Monterrey, Mexico

Recap
Inland
Navigation

1. What does it consist of?

2. What is its purpose?

Summarizatio n

1. It consists of a series of dams that convert the rivers into series of deep pools with locks alongside the dams that allow vessels to move from one pool to another.

2. Its purpose is to allow commercial vessels to move on the rivers with the assurance of adequate depth.

Inland Navigation

1. Description of Inland Navigation System
2. **Economic Evaluation**
3. Case Study

ER 1105-2-100

1. Guidance ER 1105-2-100
2. Data Navigation Data Center

http://www.iwr.usace.army.mil/ndc/index.htm

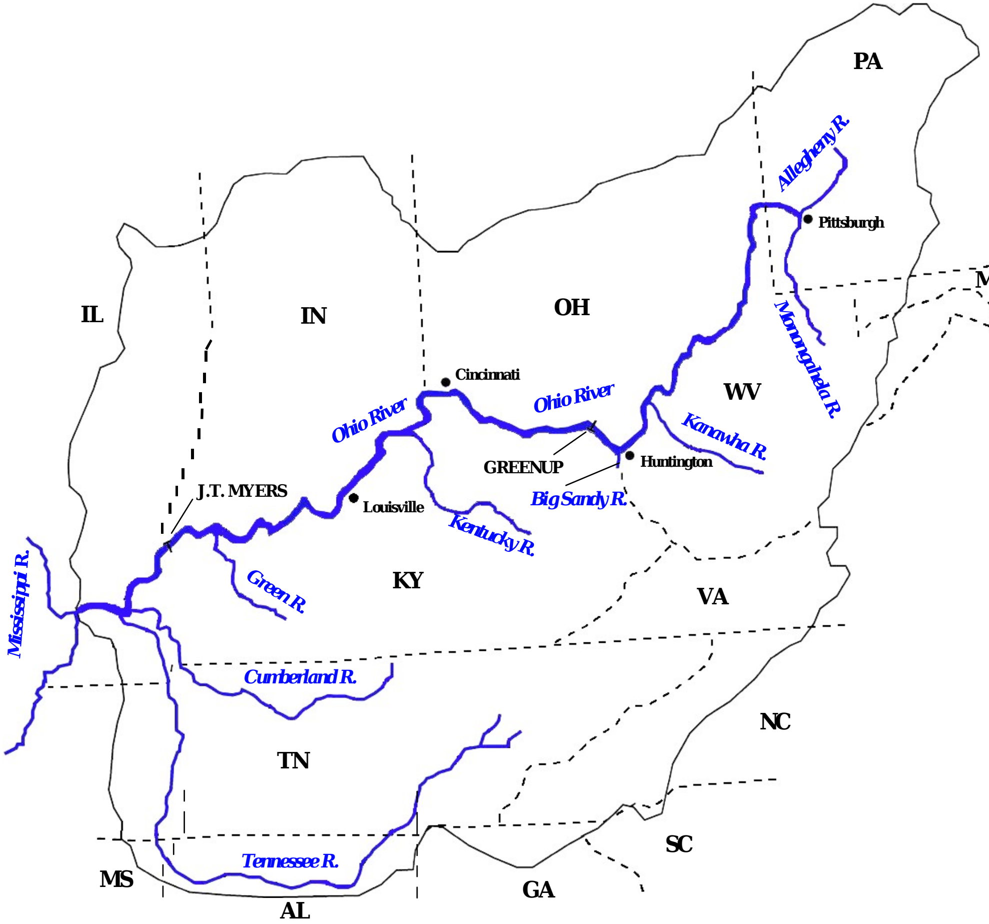
10 Steps

1. Identify the commodity types
2. Identify the study area
3. Determine current commodity flow
4. Determine current costs of waterway use
5. Determine current cost of alternative movement
6. Forecast potential waterway traffic
7. Determine future cost of alternative modes
8. Determine future cost of waterway use
9. Determine waterway use with and without project
10. Compute NED benefits

* Pages 52 – 56 of Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies March 10, 1983

Major Shippers on the Ohio River Mainstem

1. High Dependence
   - Coal Mining
   - Electric Generating
   - Coke/Steel Production
   - Petrol-Chemicals
   - Construction
2. Low Dependence
   - Agriculture
   - Wood Products

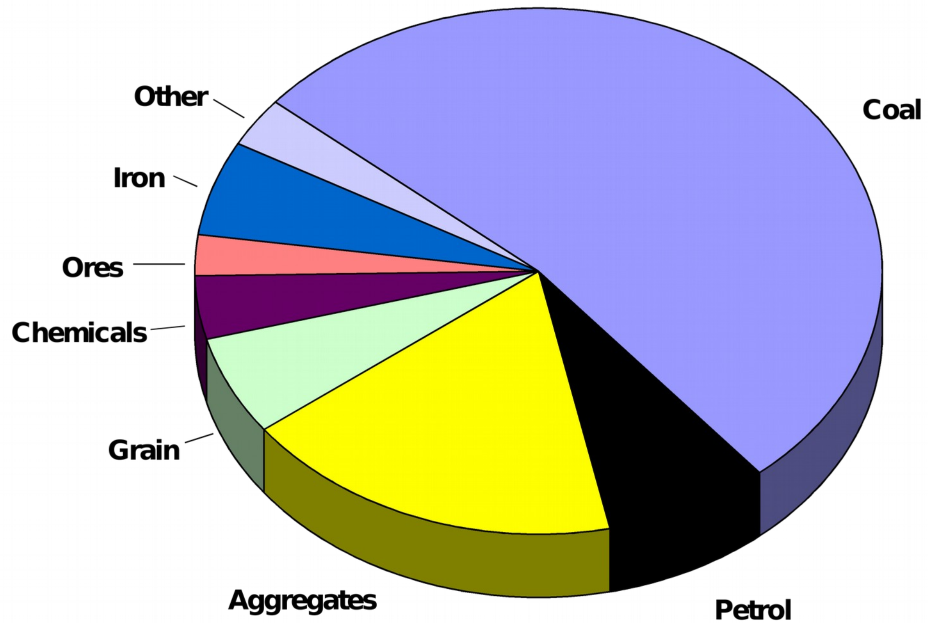


Ohio River Basin

Ohio River Mainstem Traffic

2006 Mainstem Tonnage		
Commodity Group	Tons	% Mix
Coal	127,311,257	53%
Petroleum Products	18,982,949	8%
Aggregates	43,552,342	18%
Grains	14,745,192	6%
Chemicals	9,597,285	4%
Ores & Minerals	5,978,020	2%
Iron & Steel	13,866,269	6%
Other	7,500,134	3%
Total	241,533,448	100%

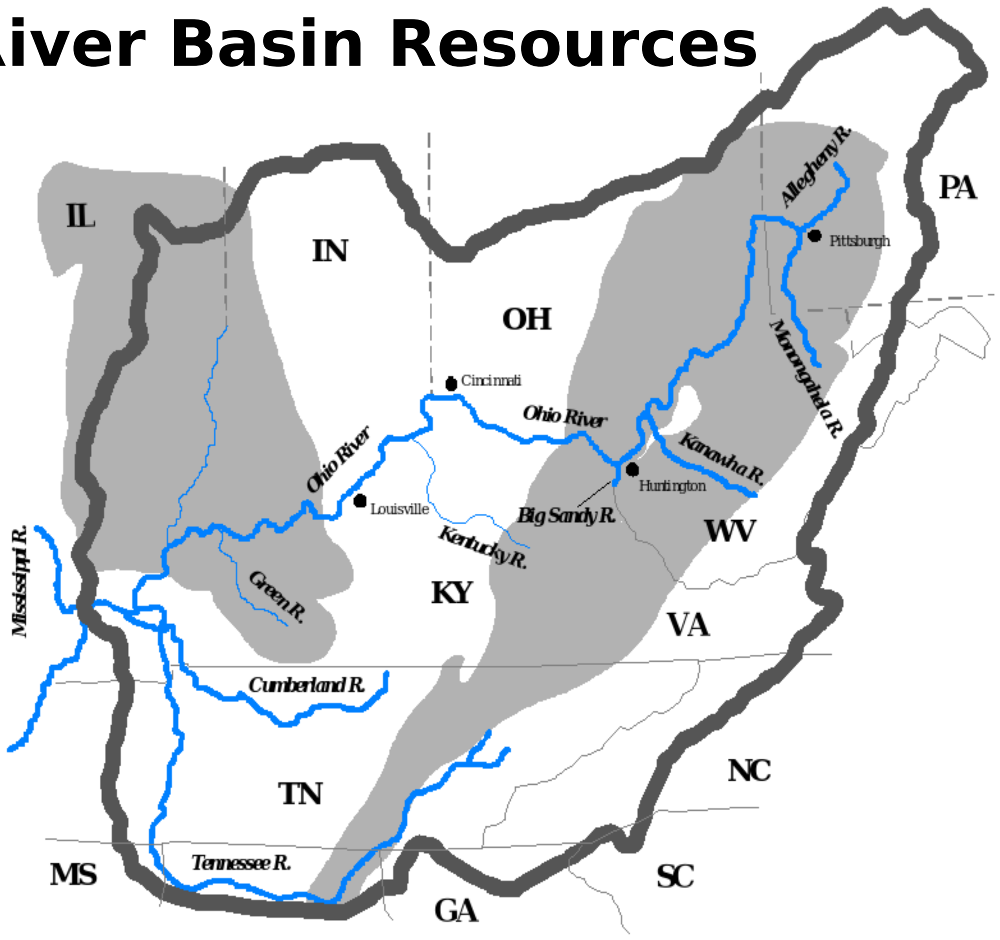
Commodity Mix



- 242 million tons in 2006
- Over 71 percent coal and stone
- Over 28 percent petrol, grains, chemicals, ores, iron & other

Ohio River Basin Resources

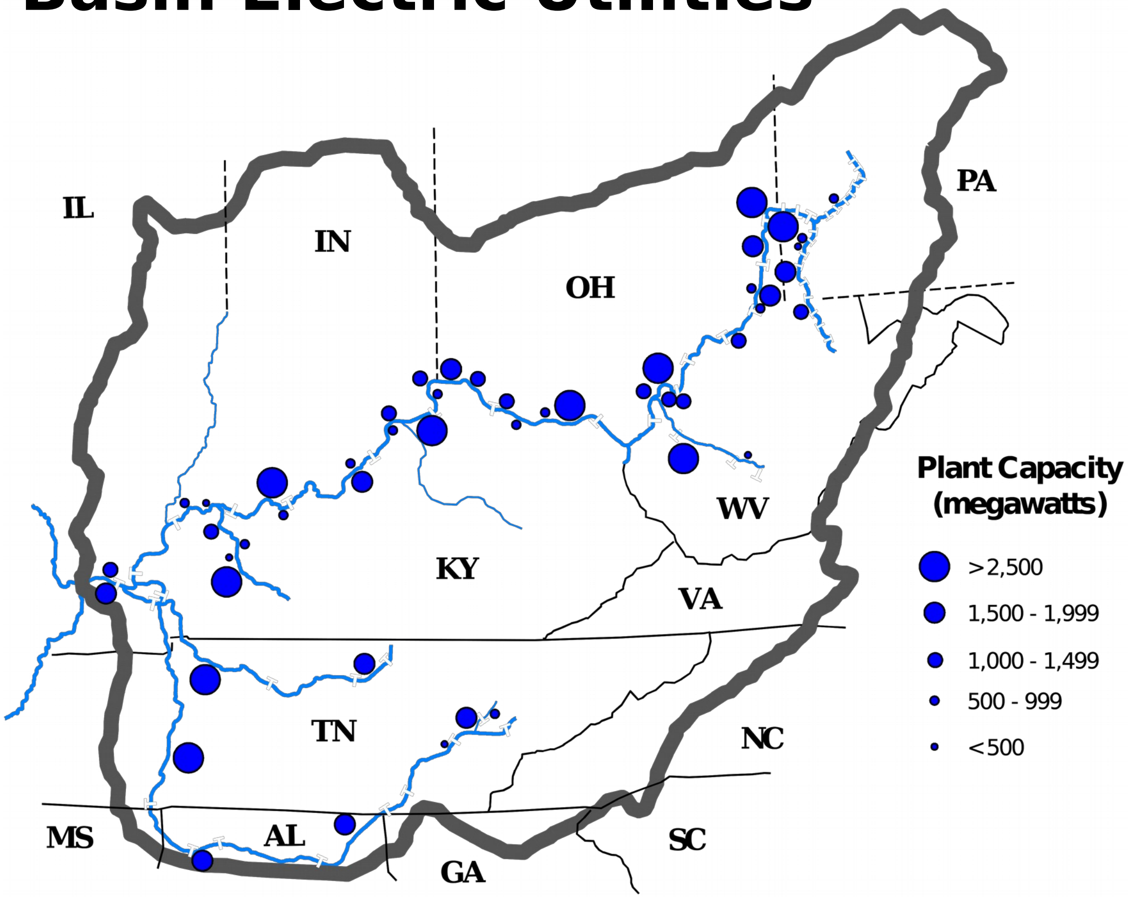
- over one-quarter of nation's reserves
- over 90 percent of highest energy reserves
- sufficient reserves to continue producing coal within the basin for the next 400 years



Ohio River Basin Coal Reserves

Ohio River Basin Electric Utilities

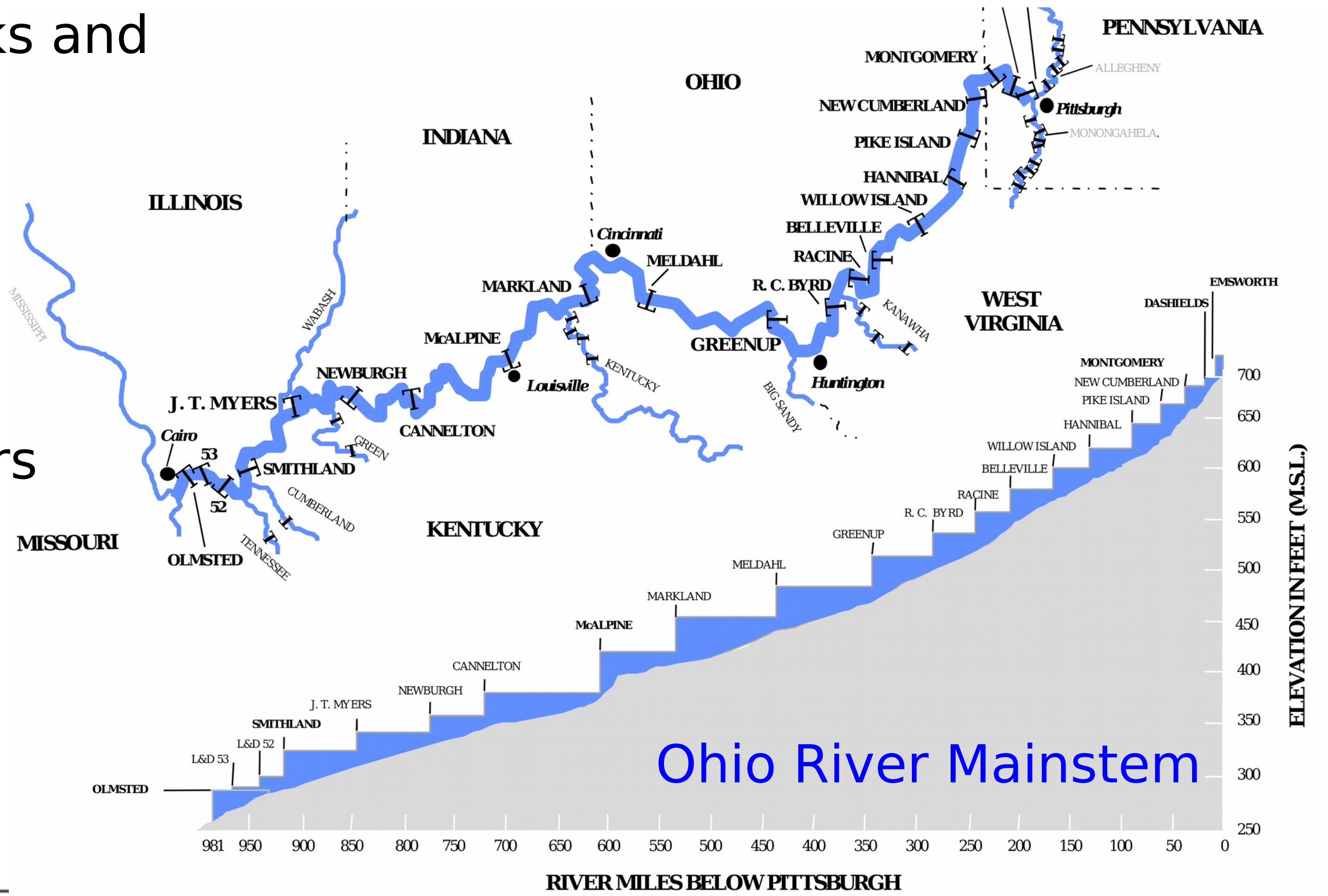
- Water supply
- Low cost transportation
- Proximity to low-sulfur coal
- Clean air requirements
- 20 percent U.S. coal-fired capacity



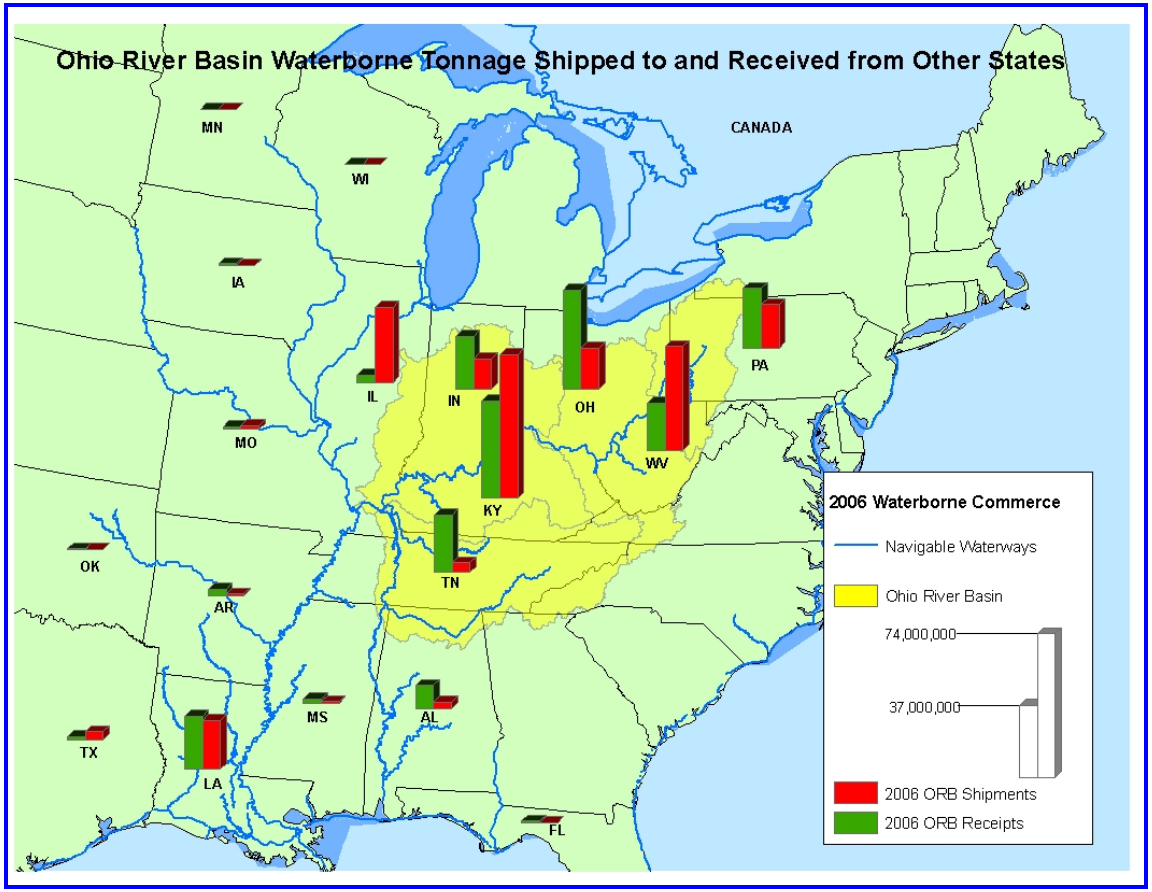
Ohio River Basin Power Plants

Ohio River Mainstem Characteristics

- 20 navigation locks and dams
- Main chambers
  - 17 1200’ x 110’
  - 3 600’ x 110’
- Auxiliary Chambers
  - 1 1200’ x 110’
  - 16 600’ x 110’
  - 3 360’ x 56’



2006 Ohio River Mainstem State Flows



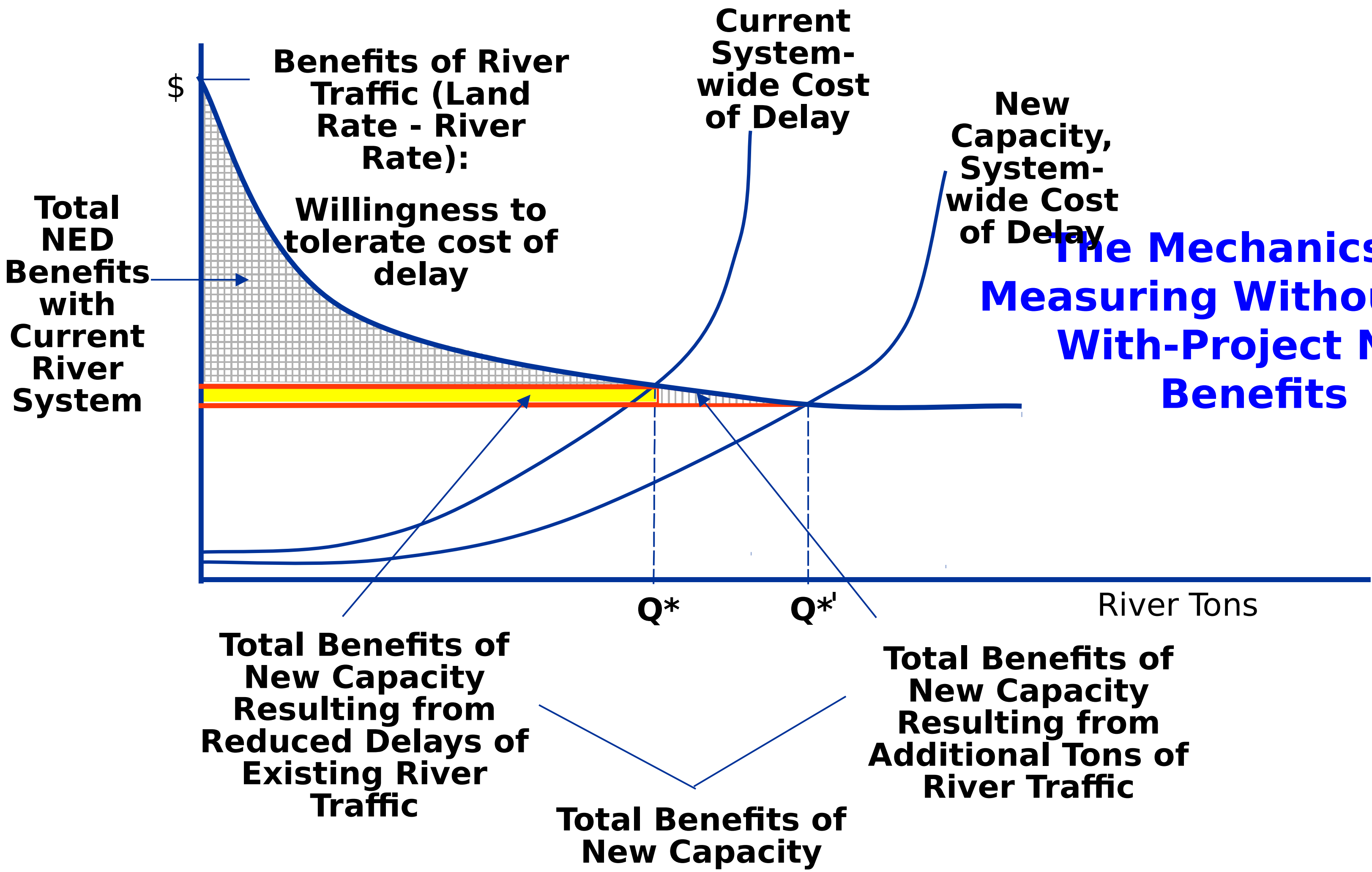
Economics

Interaction of supply and demand:

Demand = willingness to transport goods

Supply = capability of transportation system to accommodate the transport of goods

The Mechanics of Measuring Without and With-Project NED Benefits



Key Study Variables

1. Traffic Forecasts
2. Waterway and Overland Transportation Rates
3. Project Reliability - Capacity

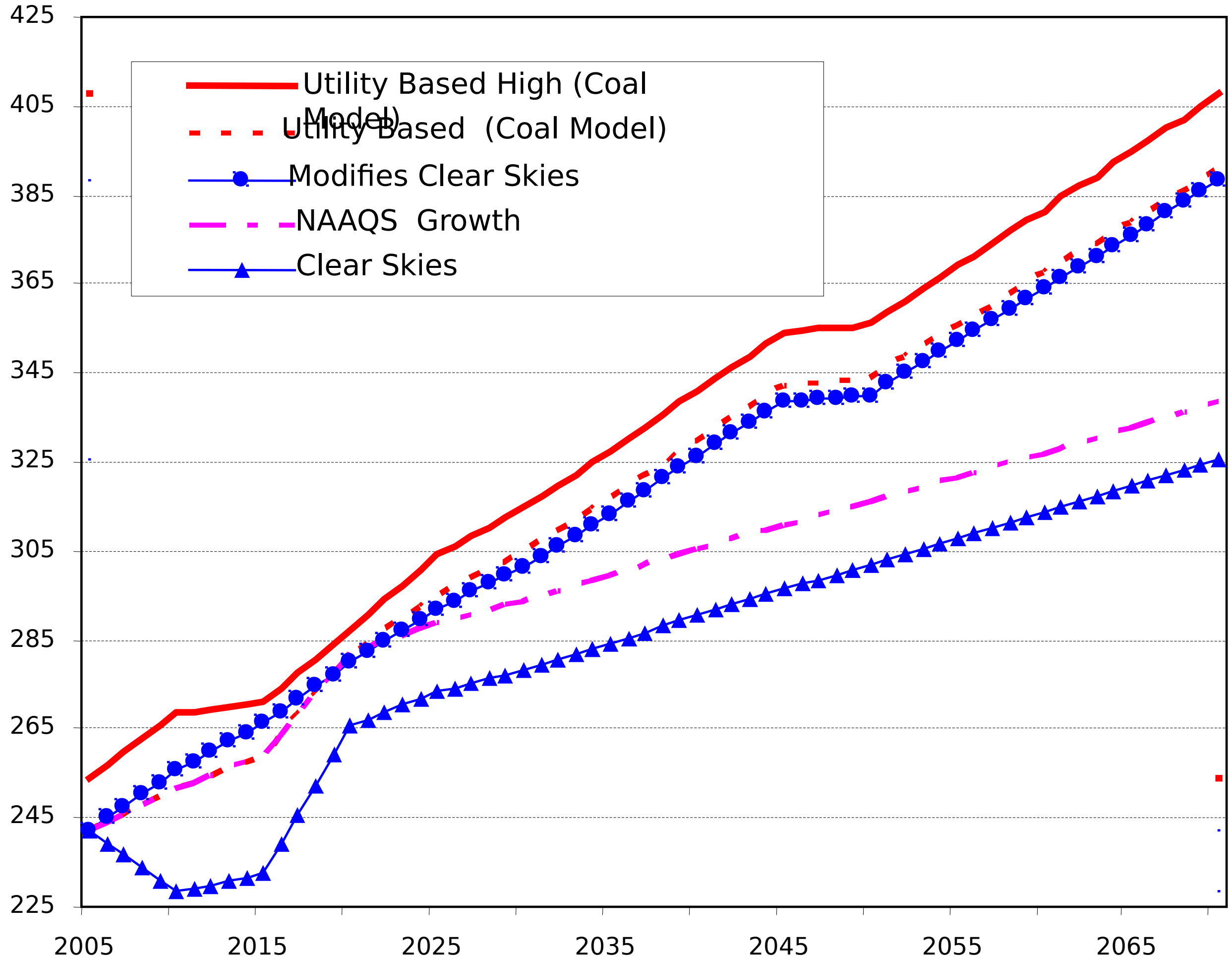
Key Study Players

1. Traffic Forecasts — Economists
2. Transportation Rates — Economists
3. Reliability — Engineers

Traffic Forecasts

How much tonnage will move on the waterway system given regional demand?

Forecasts and Uncertainty

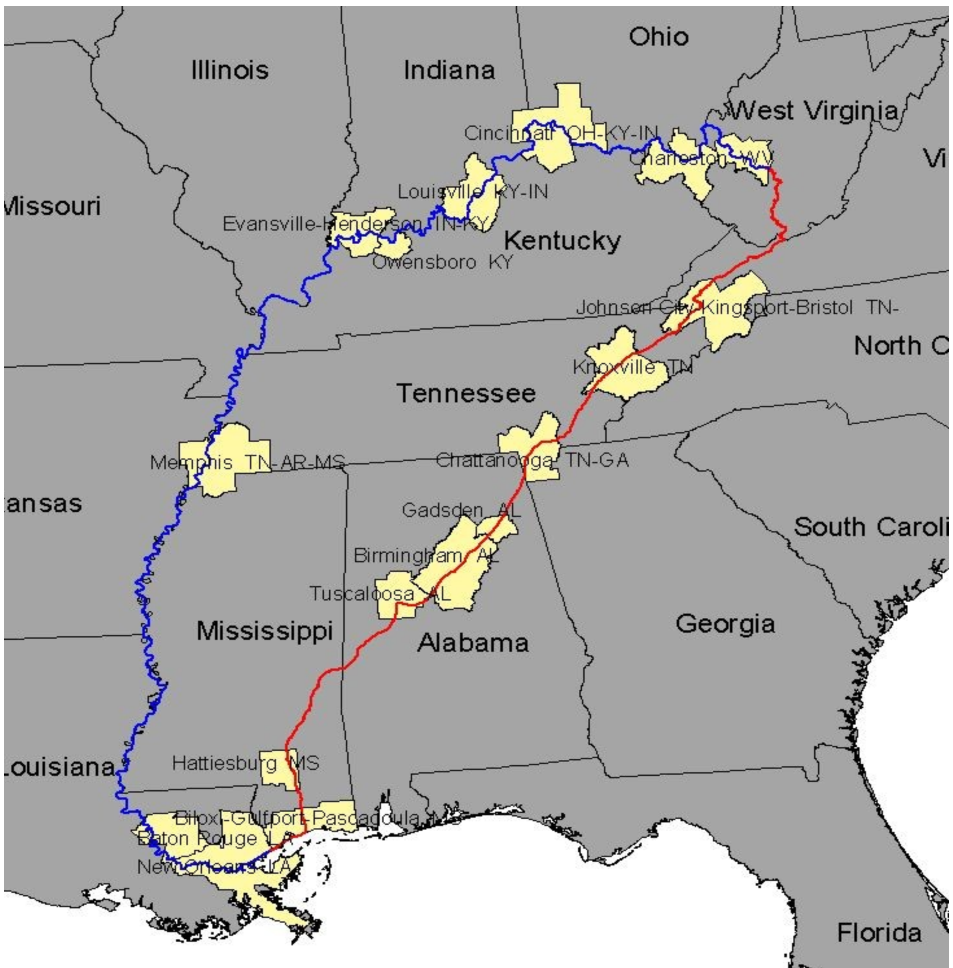


Forecasts Based on Alternative Futures

Transportation Rates

Includes all costs from ultimate origin to ultimate destination; not only the barge costs.

Transportation Rates



Water Routing

Land Routing

Metropolitan Statistical Area

Development of Transportation Rates is a
a Major Study Effort

1. Sample of movements (O-D-C)
2. Cost to rate one movement → $200 - $1,000
3. Extrapolate to population

Water Routing Transportation Cost

1. Truck to river $ 2.50/ton
2. Unload/load $ 2.00
3. Barge to plant $ 4.00
4. Unload $ 1.50

Total $ 10.00/ton

Least Cost All Overland Transportation Cost

1. Load $ 1.50/ton
2. Truck to Rail Head $ 5.00
3. Rail to plant $ 12.00
4. Unload $ 1.50

Total $ 20.00/ton

Savings per Ton

- Cost per ton by barge: $10
- Cost if shipped overland: $20
- **Savings per ton: $10/ton**

System Benefits - 2010

• Savings per ton:	$10/ton
• Tons in millions:	500 m tons
• **Total Benefits:**	**$5 billion**

Benefits Over Time Unconstrained

	Sav/ton	MTons/yr	Benefits
2010	$10	500	$5 billion
2030	$10	600	$6 billion

Savings per tons x tons per year

Reliability – One Possible Constraint

Aging infrastructure

↓

Increased closures for maintenance

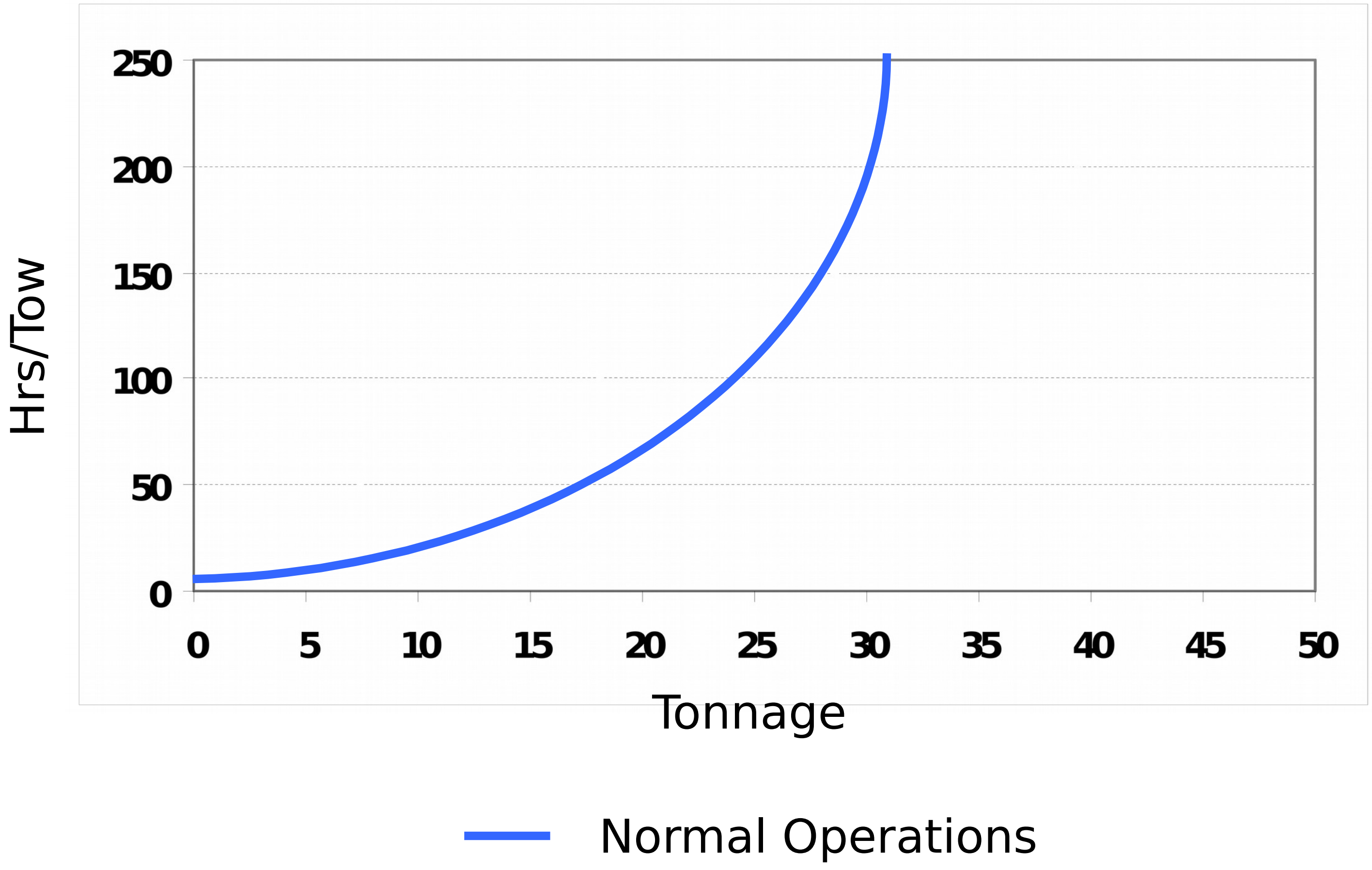
↓

Increased closures due to failures

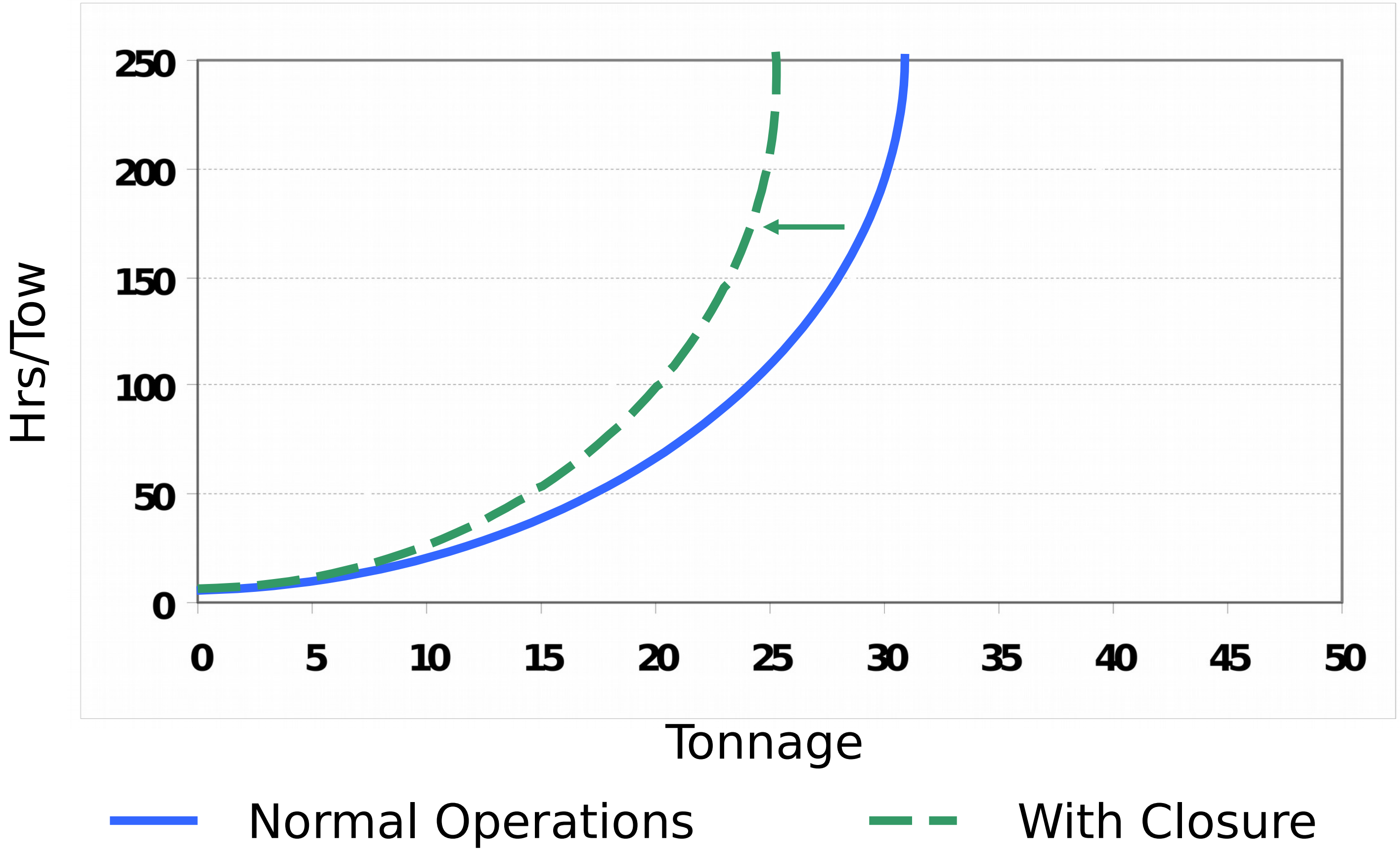
↓

Increased frequency and duration of closures

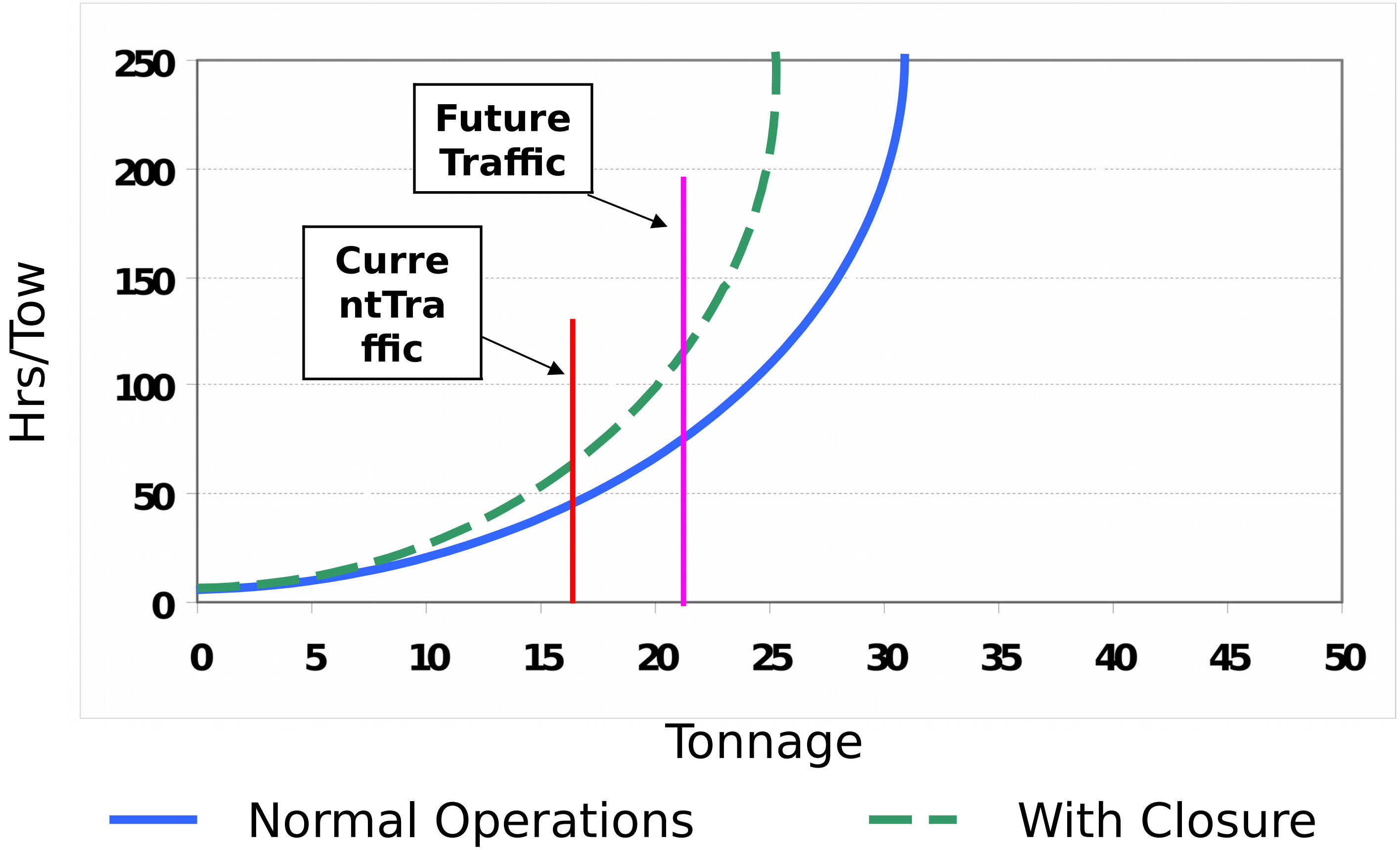
Tonnage-Transit Curve



Tonnage-Transit Curve with Closures



Tonnage-Transit Curve with Closures and Traff



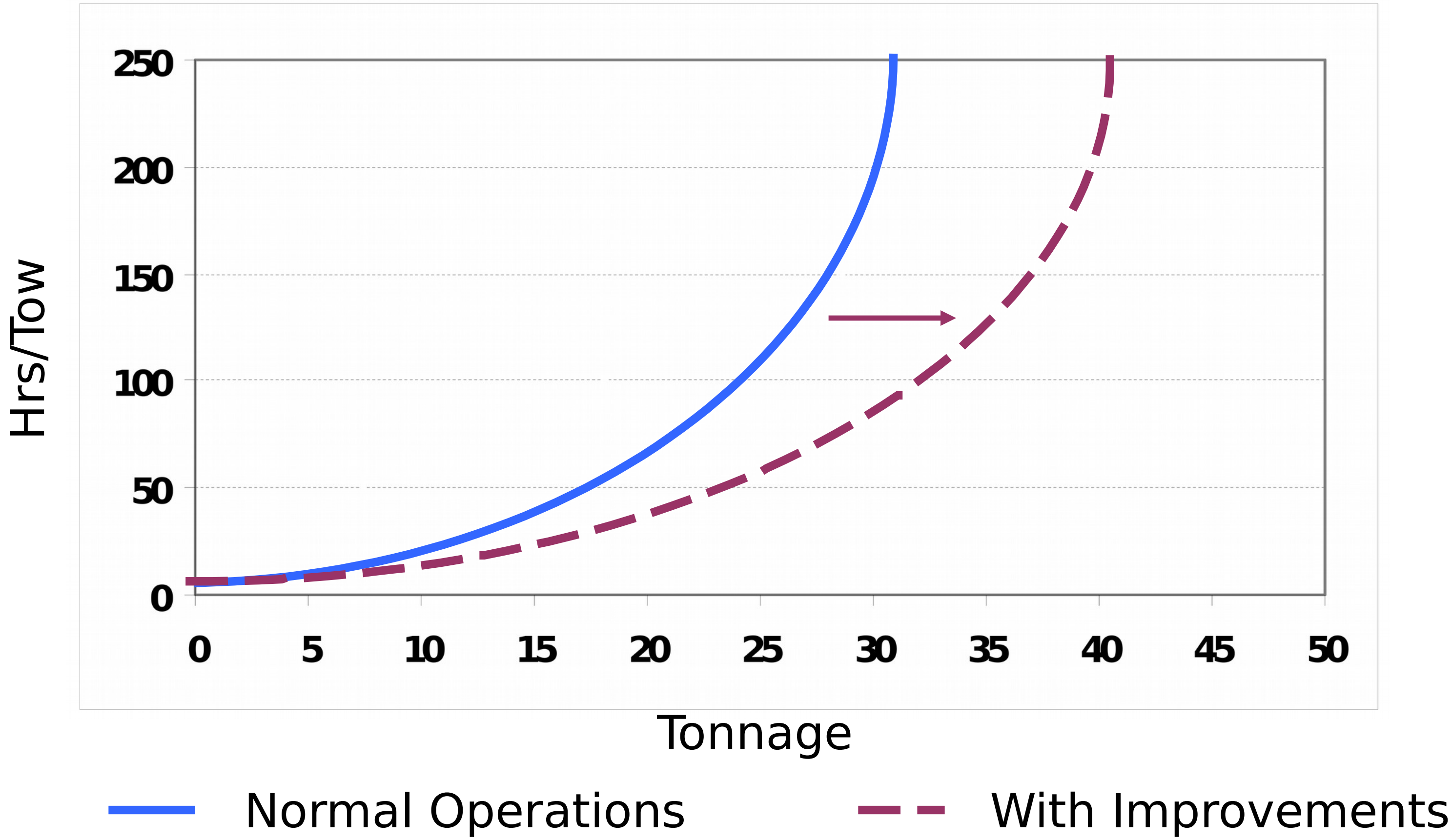
Without-Project Condition Benefits

	Sav/ton	MTons/yr	Benefits
2010	$10	500	$5 billion
2030	$ 5	600	$3 billion

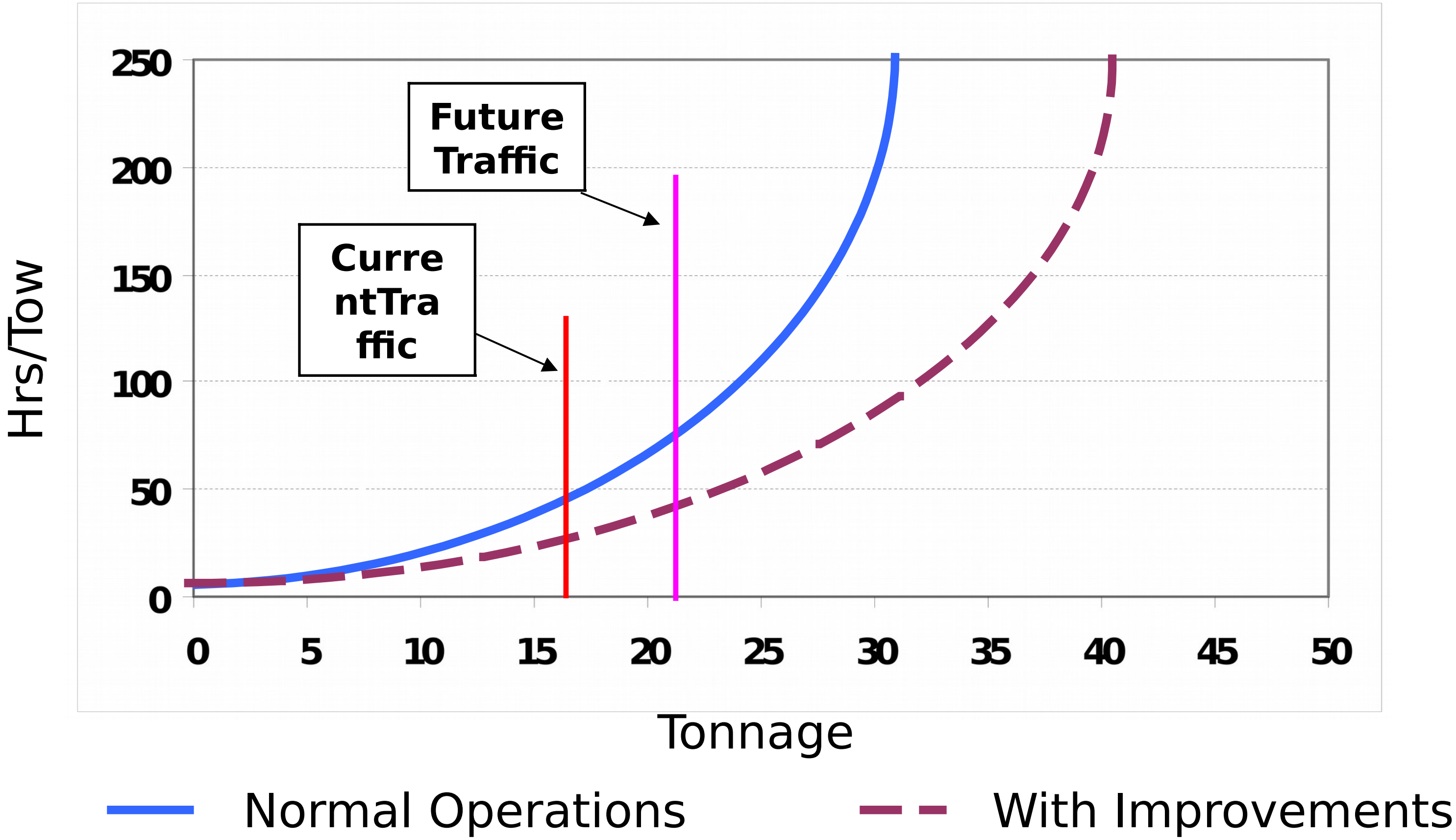
With-Project Alternative

Replace small old lock chamber with a large new lock chamber.

Tonnage-Transit Curve with Improvements



Tonnage-Transit Curve with Improvements and Traffic



With-Project Benefits

	Sav/ton	MTons/yr	Benefits
2010	$10	500	$5 billion
2030	$15	600	$9 billion

Systems Analysis

- Improving one project may increase traffic and reduce delays at that project.
- Increased traffic may increase delays at other projects.
- Benefits are the reduction in transportation costs for all shipments over the entire route, and not merely the reduction of delays at the improved project.

System Effects of Improving One Project

Improved project:	4 hour reduction in delay
Other project:	1 hour increase in delay
System:	3 hour reduction in delay

Models - Purpose

1. Develop traffic delay relationships

2. Calculate the effects on system benefits of changing traffic levels, changing project reliability, and changes in lock sizes.

Major Points Regarding Economic Procedures

1. Benefits are the savings in transportation costs between river and land routings.
2. Traffic increases and project deterioration are the major determinants of the need for navigation projects.
3. Reduced delays at one project may be partially offset by increased delays at other projects.

Any

Questions ?

or

Comments ?

Inland Navigation

1. Description of Inland Navigation System
2. Economics
3. **Case Study**

Lower Monongahela River Navigation Study

Three projects on the Monongahela River near Pittsburgh.

1. Small and inefficient locks

2. Old and unreliable structures

Key Study Parameters

1. Future Traffic Levels

2. Transportation Rates

3. Lock Size and Reliability - Capacity

Traffic Analysis

1. What commodities move on the river?

2. Key drivers?

3. Where do they originate and what is the destination?

4. What are the prospects for the future?

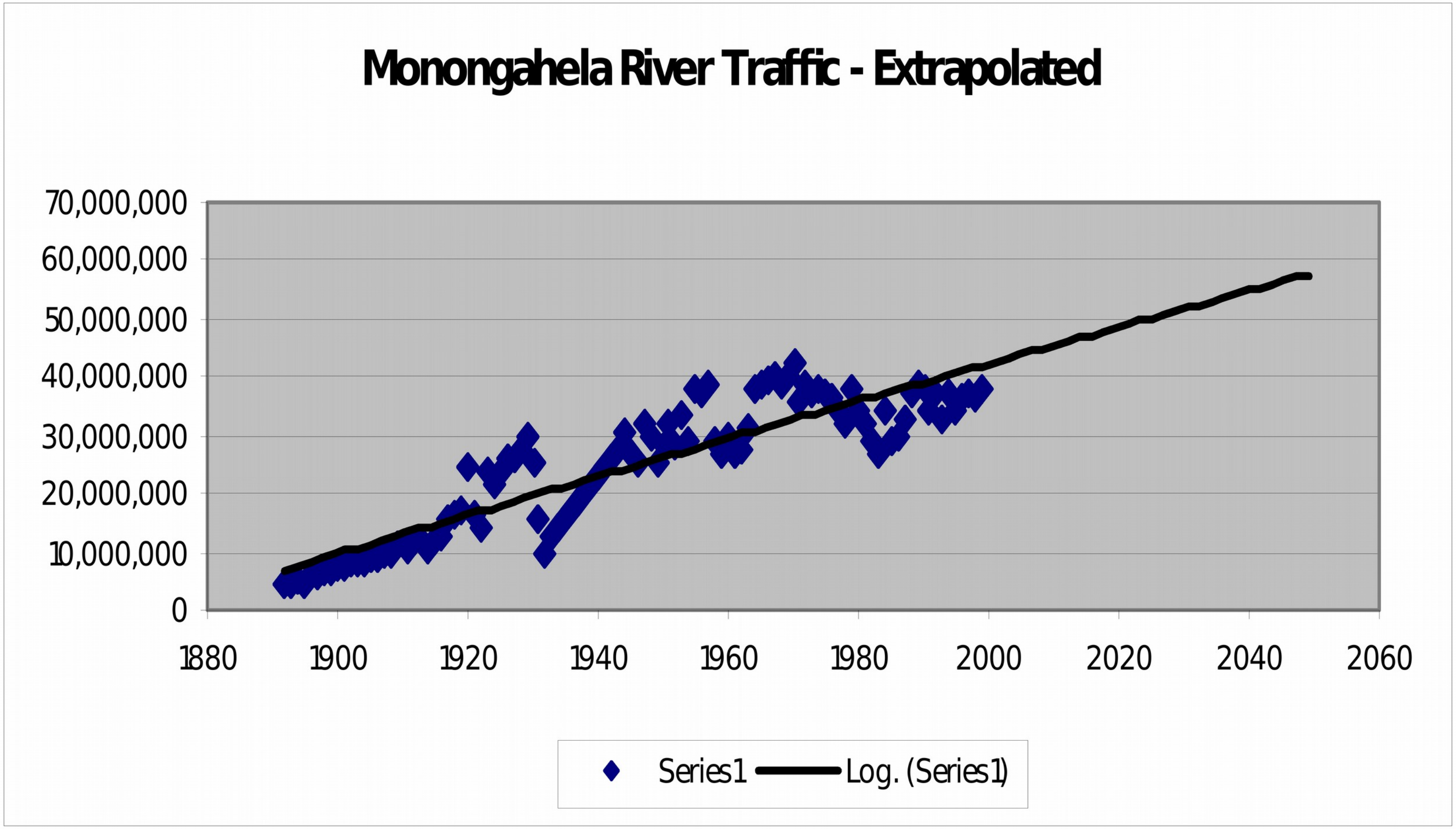
Traffic Forecasts

Traffic – predominantly coal

1. Near term – low to no growth due to high sulfur content of coal.

2. Long term – reasonable potential for growth because of large remaining reserves of coal.

Forecast River Traffic



Rate Analysis

1. Acquire list of all shipments from the waterborne commerce data base.

2. Hired TVA to develop the rates for the water-routing and least cost all-overland routes.

Reliability

Major structural problems as well as typical equipment problems.

Lock Wall

Rusted Gate

Chain out of Sprocket

Lock Delays

Economic Analysis

1. Base Condition
2. Without Alternatives
3. With Alternatives
4. NED Plan

Simulation Modeling

1. Simulation – an event tree with probabilities assigned to possible occurrences.
2. Model – mathematical representation of event tree.
3. Simulation Model – computerized version of mathematical model.

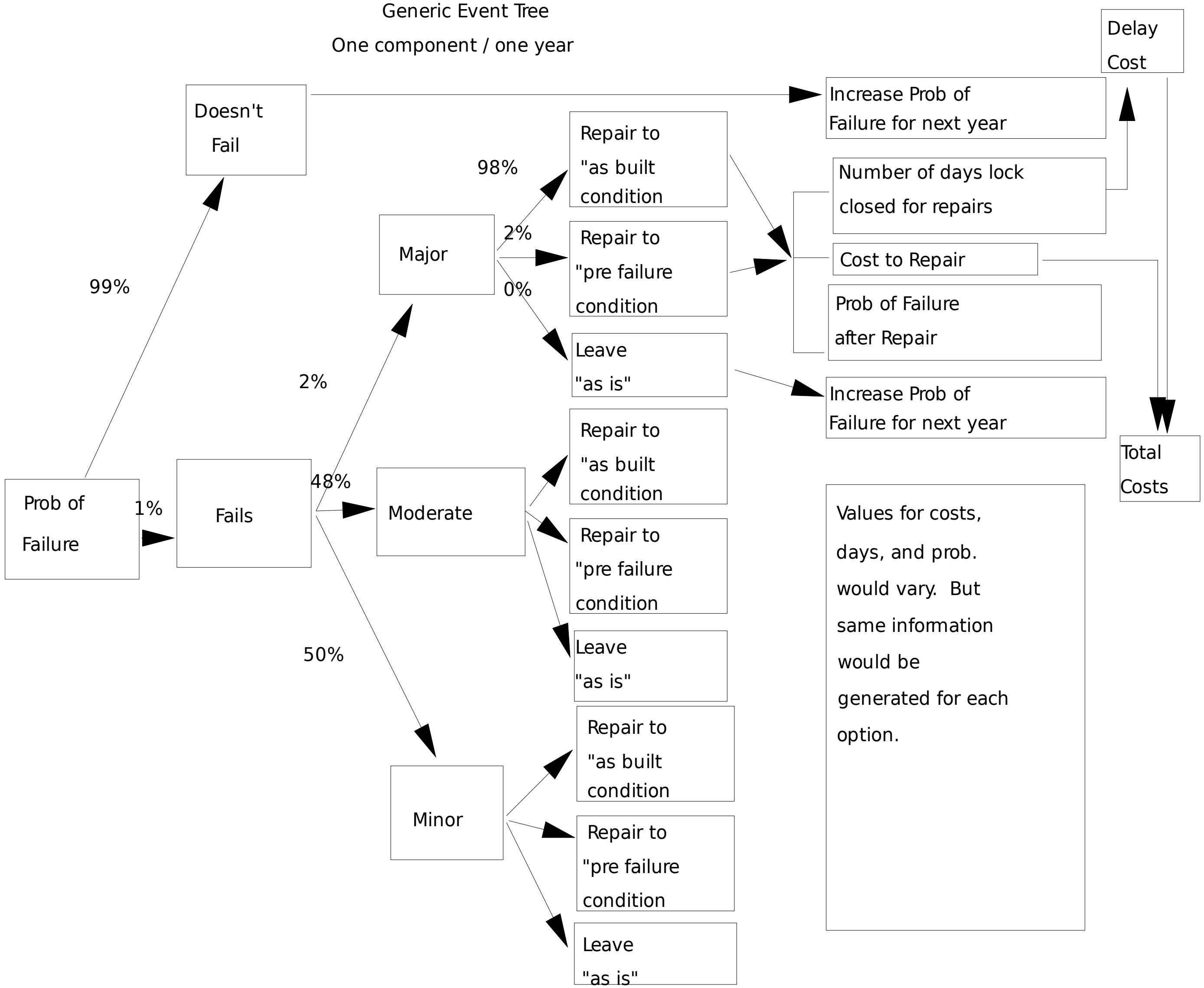
Event Tree Definition

Depicts possible linkage between conditions and possible consequences.

Event Tree Conditions and Consequences

1. Probability of breakdowns
2. Time to repair
3. Cost of repairs
4. Consequences of breakdowns

Typical Event Tree



Simulation Process

1. Simulation – generate random number to compare to probabilities on event trees. Use probabilities to trace path to possible consequences (do for each year).
2. Life cycle analysis – perform simulation of event tree for each year in time period of evaluation (50 years).
3. Iterations – perform life cycle computations a large number of times to ensure all possible paths are simulated.

Simulation Process – Depiction

Simulation – Simulate possible events as depicted in Event Tree

Event Tree

Life Cycle Analysis – Multiple Simulations of Event Tree

Event Tree - - - - - - - - - - - - - Event Tree

2010 2060

Iterations – Multiple Life Cycle Runs

Life Cycle Analysis - 1

Event Tree - - Event Tree

2010 2060

Life Cycle Analysis - 2

Event Tree - - Event Tree

2010 2060

Etc.

Base Condition

What is the future if we continue to operate and maintain the projects in the same manner as we have in the past?

Probability of Failure

Year	Probability of Failure
2010	5%
2030	20%
2050	50%

Base Condition

- Projects would become increasingly unreliable at a loss of $300 million in benefits annually.
- A year-long closure would save $3 million in O&M.
- Net loss of NED benefits of $297 million annually.

Without-Project Alternatives

Possible corrective actions to ameliorate the problems:

1. Rehabilitation
2. Traffic Management
3. Reconstruction

Without-Project Economics

Average Annual Values

Benefits:	$300 million
Costs:	$103 million
Net Benefits:	$197 million
B/C Ratio:	3:1

Residual Problems

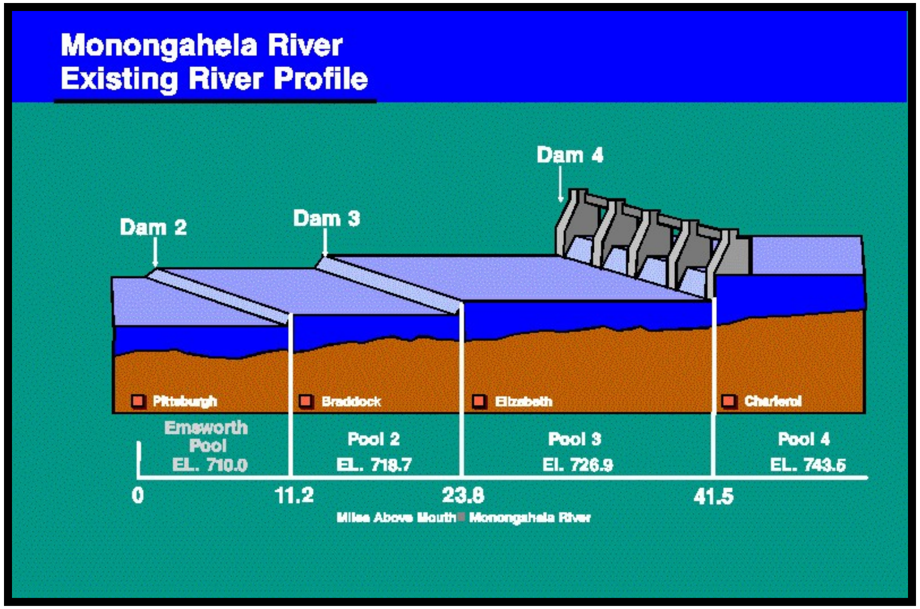
1. Intermittent traffic delays
2. Long processing times
3. High O&M costs

With-Project Alternative

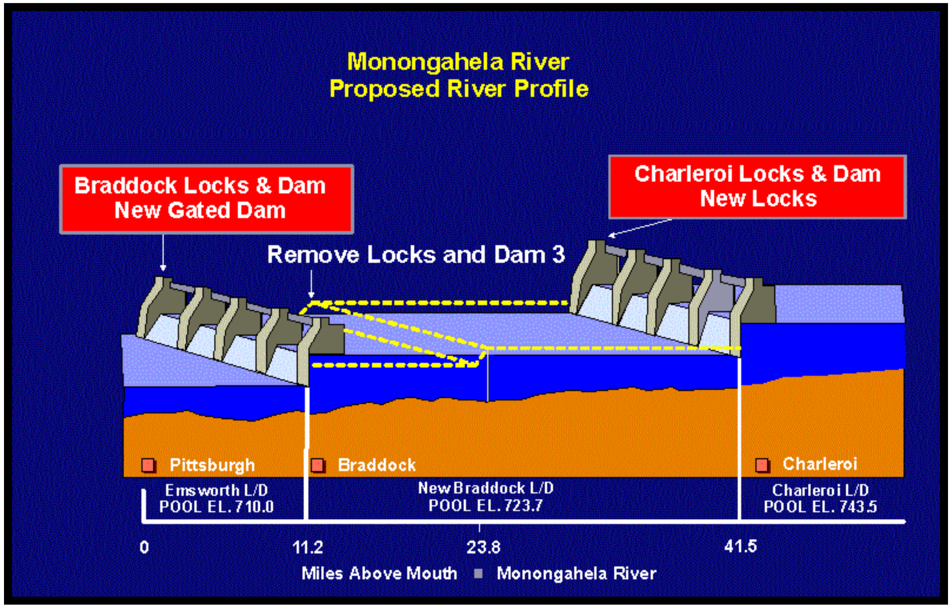
1. Replace small locks with large locks.

2. Eliminate one of three projects altogether.

Existing Profile



Future Profile



Economics
(average annual; $ in millions)

	Without	With
Benefits:	$ 300	$ 400
Costs:	$ 103	$ 122
Net Benefits:	$ 197	$ 278
B/C Ratio:	3:1	4:1

Economics for Scenarios
(average annual; $ in millions)

	Scenario 1 (low forecasts)	Scenario 2 (high forecasts)
Benefits:	$ 325	$ 400
Costs:	$ 122	$ 122
Net Benefits:	$ 228	$ 278
B/C Ratio:	1.9:1	4:1

What if costs were significantly higher for the With-Project Condition?

	Without	With
Benefits:	$ 300	$ 400
Costs:	$ 103	$ 200
Net Benefits:	$ 197	$ 200
B/C Ratio:	3:1	2:1

Areas of Greatest Uncertainty

1. Traffic Forecasts

2. Project Reliability

3. Period of Construction

Questions

Planning Center of Expertise for Inland Navigation

Huntington HQ – (304) 399-5635